



The Anatomical Course of the Lateral Femoral Cutaneous Nerve with Special Attention to the Anterior Approach to the Hip Joint

Rudin, D ; Manestar, M ; Ullrich, O ; Erhardt, J ; Grob, K

Abstract: BACKGROUND: Injury to the lateral femoral cutaneous nerve (LFCN) is a risk during the operative anterior approach to the hip joint. Although several anatomical studies have described the proximal course of the nerve in relation to the anterior superior iliac spine (ASIS) and the inguinal ligament, the distal course of the LFCN in the proximal aspect of the thigh has not been sufficiently studied. The aim of this cadaveric study was to examine the branching pattern of the nerve, with special consideration to the anterior approach to the hip joint. METHODS: Twenty-eight cadaveric hemipelves from 18 donors (10 paired and 8 unpaired specimens) were dissected. The LFCN branches were localized proximal to the inguinal ligament and traced distally into the area of the proximal aspect of the thigh. Distribution patterns of the nerve with respect to its relationship to the ASIS and the internervous plane of the anterior approach to the hip joint were recorded. RESULTS: We found 3 different branching patterns of the LFCN: sartorius-type (in 36% of the specimens), characterized by a dominant anterior nerve branch coursing along the lateral border of the sartorius muscle with no, or only a thin, posterior branch; posterior-type (in 32%), characterized by a strong posterior nerve branch; and fan-type (in 32%), characterized by multiple spreading nerve branches of equal thickness. In 50% of the specimens, the LFCN divided into 2 branches superior to the inguinal ligament. Sixty-two percent of the LFCN branches entered the proximal aspect of the thigh medial to the ASIS; 27%, above; and 11%, lateral to the ASIS. The LFCN consistently coursed within the deep layer of the subcutaneous fat tissue. CONCLUSIONS: Injury to branches of the LFCN cannot be avoided in approximately one-third of surgical dissections that use the anterior approach to the hip joint. To protect the anterior branch of the LFCN, the skin incision should be as lateral as possible. The posterior branch of the LFCN is most vulnerable in the proximal aspect of the anterior approach to the hip joint, where it can be expected to course within the deep layer of the subcutaneous tissue.

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The Anatomical Course of the Lateral Femoral Cutaneous Nerve with Special Attention to the Anterior Approach to the Hip Joint

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Background: Injury to the lateral femoral cutaneous nerve (LFCN) is a risk during the operative anterior approach to the hip joint. Although several anatomical studies have described the proximal course of the nerve in relation to the anterior superior iliac spine (ASIS) and the inguinal ligament, the distal course of the LFCN in the proximal aspect of the thigh has not been sufficiently studied. The aim of this cadaveric study was to examine the branching pattern of the nerve, with special consideration to the anterior approach to the hip joint.

Methods: Twenty-eight cadaveric hemipelves from 18 donors (10 paired and 8 unpaired specimens) were dissected. The LFCN branches were localized proximal to the inguinal ligament and traced distally into the area of the proximal aspect of the thigh. Distribution patterns of the nerve with respect to its relationship to the ASIS and the internervous plane of the anterior approach to the hip joint were recorded.

Results: We found 3 different branching patterns of the LFCN: sartorius-type (in 36% of the specimens), characterized by a dominant anterior nerve branch coursing along the lateral border of the sartorius muscle with no, or only a thin, posterior branch; posterior-type (in 32%), characterized by a strong posterior nerve branch; and fan-type (in 32%), characterized by multiple spreading nerve branches of equal thickness. In 50% of the specimens, the LFCN divided into ≥ 2 branches superior to the inguinal ligament. Sixty-two percent of the LFCN branches entered the proximal aspect of the thigh medial to the ASIS; 27%, above; and 11%, lateral to the ASIS. The LFCN consistently coursed within the deep layer of the subcutaneous fat tissue.

Conclusions: Injury to branches of the LFCN cannot be avoided in approximately one-third of surgical dissections that use the anterior approach to the hip joint. To protect the anterior branch of the LFCN, the skin incision should be as lateral as possible. The posterior branch of the LFCN is most vulnerable in the proximal aspect of the anterior approach to the hip joint, where it can be expected to course within the deep layer of the subcutaneous tissue.

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The use of the direct anterior approach has gained popularity in recent years in total hip arthroplasty and the treatment of femoroacetabular impingement¹⁻⁴. It remains a standard approach to the hip joint in pediatric orthopaedic surgery for developmental hip dysplasia or septic arthritis. In adult orthopaedic surgery, it is used to expose the anterolateral aspect of the acetabulum, to access the femoral head and neck for the treatment of femoral head fractures, and to access the region for biopsies, for the excision of ectopic bone, and for the treatment of an infected hip⁵⁻¹¹. The anterior approach to the hip joint takes

advantage of the internervous plane between the sartorius muscle (femoral nerve) and the tensor fasciae latae muscle (superior gluteal nerve). Despite the soft tissue-preserving nature of the anterior approach, there is a great danger of damaging the lateral femoral cutaneous nerve (LFCN)¹²⁻¹⁴; the literature shows diverse rates of injury to the LFCN of between 0.1% and 81%^{13,15-17}. Although injury to the LFCN does not represent a major neurological complication, patients may report numbness or a burning sensation in the anterolateral region of the thigh and, in the worst cases, dysesthesia.

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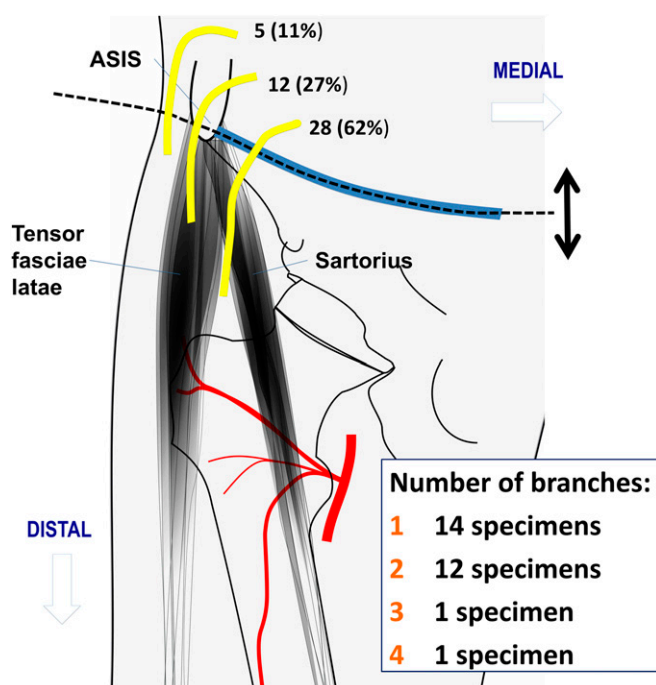


Fig. 1
Schematic drawing of the right hip. At the level of the ASIS, in total, 45 LFCN branches in 28 cadaveric hemipelves were found. The course of all 45 dissected branches of the LFCN in relation to the ASIS is shown. Twenty-eight (62%) of the branches entered the proximal aspect of the thigh medial to the ASIS, 12 (27%) entered just above, and 5 (11%) entered lateral to the ASIS. In 50% (14) of the specimens, the LFCN divided in 2 to 4 branches superior to the inguinal ligament (black dotted line). In 50% (14), only 1 nerve branch could be found (see inset).

The LFCN is a purely sensory nerve, and its fibers usually derive from the second and third lumbar nerve. The nerve emerges from the lateral border of the psoas major, follows an intrapelvic course crossing the iliacus obliquely, and runs toward the anterior superior iliac spine (ASIS). The nerve pierces the fascia lata beneath the inguinal ligament and runs laterally and distally within the subcutaneous tissue of the anterolateral region of the thigh^{18,19}. The exit from the intrapelvic passage or entry into the thigh region can vary, as several anatomical studies have shown¹⁹⁻²⁶. While most anatomical textbooks do not describe the distribution pattern of the LFCN in the proximal aspect of the anterolateral thigh region²⁷⁻³⁰, some authors describe a division of the LFCN into an anterior (femoral) and posterior (gluteal) branch after passing behind or through the inguinal ligament^{18,23,24,31}. There is a lack of detailed information about the distribution and variation in the course of the LFCN in the proximal aspect of the thigh, the region in which the anterior approach to the hip joint is performed.

The aim of this study was to describe the course of the LFCN in the proximal aspect of the thigh with respect to the anterior approach to the hip joint and to provide guidance on how the LFCN can be protected during surgery.

Materials and Methods

We studied 28 cadaveric hemipelves (10 paired and 8 unpaired; 12 specimens from male donors and 16 from female donors; mean age at death of 79 years; range, 65 to 93 years). The specimens were embalmed in either a formalin-based ($n = 20$) or Thiel ($n = 8$) solution²⁷. None of the cadavers showed any evidence of previous trauma or surgery to the femur or hip joint.

The following dissection protocol was applied. Each lower limb was first placed on a dissection table, and the branches of the LFCN were localized proximal to the inguinal ligament through an ilioinguinal approach³². To improve visualization, a long incision of 30 cm was made following the anterior half of the iliac crest to the ASIS. From there, the incision was curved downward, over the muscle belly of the tensor fasciae latae. All nerve branches of the LFCN were carefully traced distally in the subcutaneous tissue of the proximal aspect of the thigh. The branching pattern and distribution of the LFCN within the proximal aspect of the thigh were described with respect to 3 landmarks: the lateral border of the sartorius, the medial border of the tensor fasciae latae, and the ASIS.

Results

There was a high variability in the number of LFCN branches at the level of the ASIS. In total, we found 45 branches of the LFCN in the 28 cadaveric hemipelves studied. In 14 specimens, there was only 1 branch that could be traced; in 12 specimens, 2 branches; in 1 specimen, 3 branches; and in another specimen, 4 branches. In the 14 specimens with ≥ 2 branches, the LFCN divided superior to the inguinal ligament, whereas in the specimens with 1 branch, it divided inferiorly. Twenty-eight (62%) of the 45 LFCN branches entered the proximal aspect of the thigh medial to the ASIS; 12 (27%) entered just above, and 5 (11%) entered lateral to the ASIS (Fig. 1). In the proximal aspect of the thigh, distal to the ASIS, the subcutaneous fat tissue was consistently divided into a superficial and a deep layer by a weak fascia, and the nerve branches of the LFCN regularly ran within the deep layer (Figs. 2 and 3).

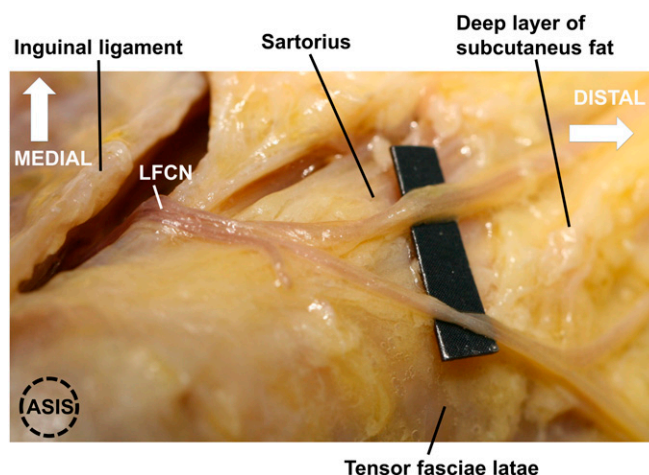


Fig. 2
The course of the LFCN medial to the ASIS is shown. The LFCN exits the intrapelvic passage beneath the inguinal ligament and divides into an anterior and a posterior branch. The nerve runs within the deep layer of the subcutaneous fat. Black paper was placed beneath the nerve branches for better visualization.

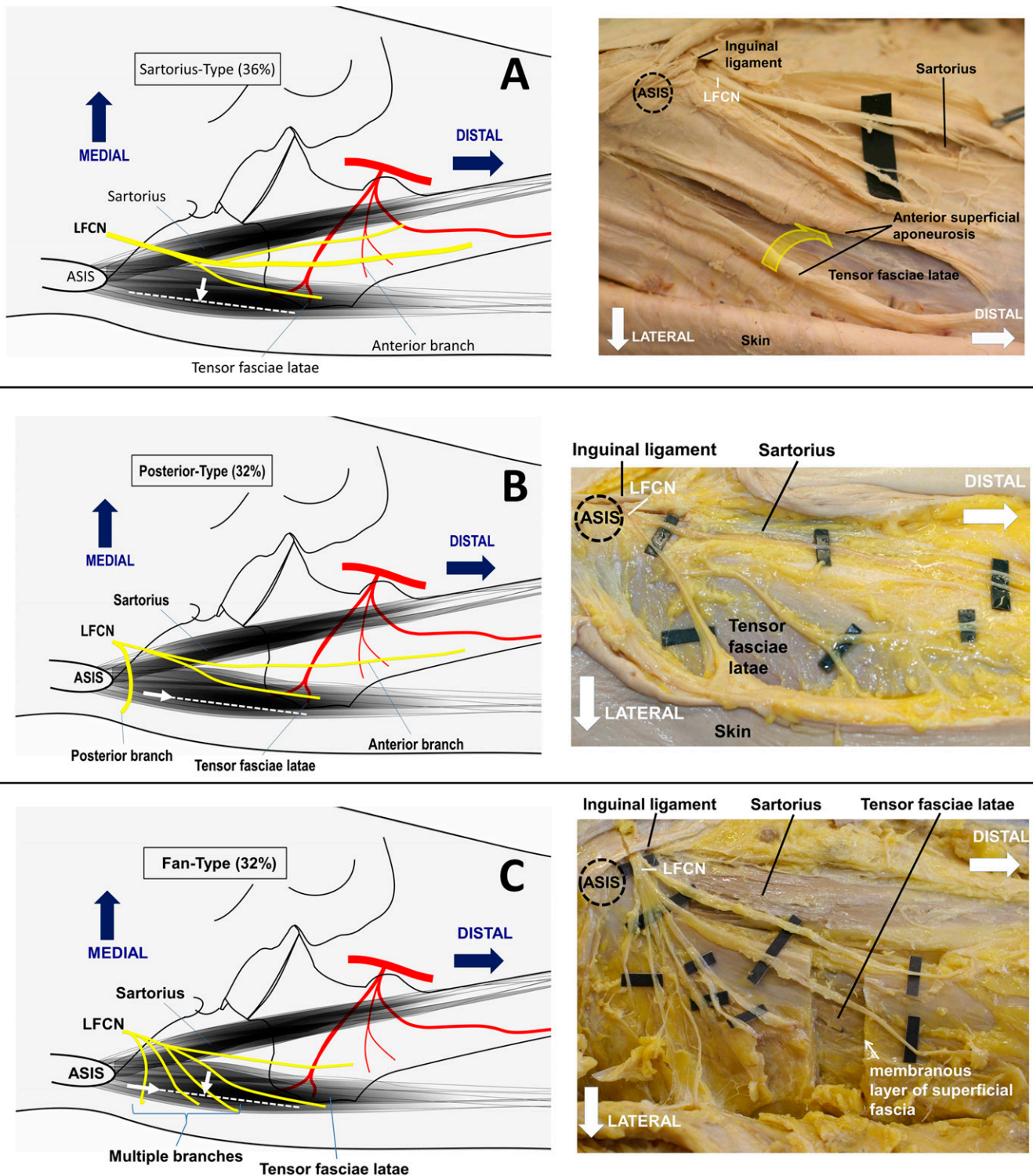


Fig. 3

Figs. 3-A, 3-B, and 3-C The 3 observed types of branching pattern of the LFCN. Black paper was placed beneath the nerve branches for better visualization (right panels). **Fig. 3-A, left panel** Schematic drawing of the sartorius type of branching pattern. A dominant anterior branch runs along the lateral border of the sartorius muscle and further branches in the anterior aspect of the thigh. No other branch, or only a very thin posterior branch, can be found. Injury to the nerve can be avoided by a lateral incision away from the lateral border of the sartorius muscle (small white arrow and dotted line).

Fig. 3-A, right panel Anterolateral view of a right hip region showing the sartorius type of LFCN branching pattern. A dominant anterior branch pierces

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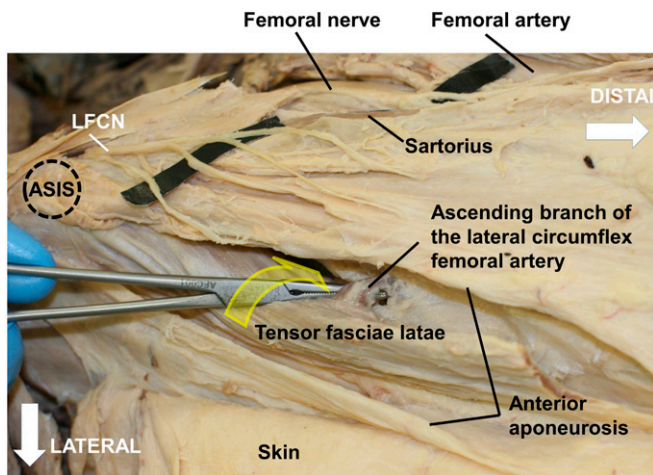


Fig. 4
Anterolateral view of a right hip region showing the sartorius type of LFCN branching pattern. Black paper was placed beneath the nerve branches for better visualization. The strong anterior branch of the LFCN can be protected by a lateral incision of the anterior superficial aponeurosis of the tensor fasciae latae. The deep surgical dissection shows the ascending branch of the lateral circumflex femoral artery (indicated by the Pean clamp). The yellow arrow indicates the anterior approach to the hip joint.

Branching Patterns of the LFCN

Three types of branching pattern of the LFCN were observed.

Sartorius-Type

In 10 (36%) of the 28 specimens, a dominant anterior branch of the LFCN coursed along the lateral border of the sartorius muscle. No other branch, or only a very thin posterior branch, could be found (Figs. 3-A and 4).

Posterior-Type

In 9 (32%) of the 28 specimens, a strong posterior branch, equal in thickness to, or thicker than, the anterior branch, could be traced. The posterior branch of the LFCN consistently branched off laterally and crossed the medial border of the tensor fasciae

latae muscle immediately distal to the ASIS (Fig. 3-B). The posterior branch regularly ran together with 1 or 2 fine vessels within a membranous layer that separated the superficial subcutaneous fat from the deep subcutaneous fat.

Fan-Type

In 9 (32%) of the 28 specimens, multiple nerve branches of equal thickness spread over the anterolateral region of the proximal aspect of the thigh, crossing over the tensor fasciae latae muscle and the lateral border of the sartorius (Figs. 3-C and 5).

Discussion

The Hueter, or Smith-Petersen³³, anterior approach was used by Judet and Judet to expose the hip joint in arthroplasty techniques beginning in 1947^{34,35}. The approach takes advantage of the interval between the sartorius and tensor fasciae latae muscles to access the hip joint. The upper aspect of this approach provides visualization of the entire ilium and hip joint. The distal extension is limited by multiple nerve branches that supply anterolateral parts of the quadriceps muscle group³⁶. The initial technique involved partial removal of the tensor fasciae latae from the anterolateral aspect of the iliac crest and the release of the reflected head of the rectus femoris. Nearly all surgery of the hip can be performed through this approach, and it remains a standard approach in pediatric orthopaedic surgery for the treatment of developmental hip dysplasia, for femoral neck and pelvic osteotomies, and for articular arthrodesis. In adult orthopaedic surgery, it is used to expose the femoral head, the femoral neck, and the anterior aspect of the acetabulum. Since the initial description, the approach has been modified to allow exposure of the acetabulum and femur through a single, anterior incision that does not require the release of muscles or tendons from the pelvis or femur, and it has gained popularity as a versatile approach for minimally invasive hip arthroplasty and for the treatment of femoroacetabular impingement². However, the LFCN and its branches may be jeopardized during this approach. Although injury to the LFCN does not represent a major neurological complication, damage can cause sensory loss, from temporary to

Fig. 3 (continued)

the fascia lata beneath the inguinal ligament and runs along the lateral border of the sartorius muscle distally within the subcutaneous tissue of the anterolateral region of the thigh. The laterally incised and lifted anterior superficial aponeurosis of the tensor fasciae latae protects the dominant anterior branch of the LFCN. The yellow arrow indicates the anterior approach to the hip joint. **Fig. 3-B, left panel** Schematic drawing of the posterior type of LFCN branching pattern. A strong posterior branch, equal in thickness to, or thicker than, the anterior branch runs laterally and crosses the medial border of the tensor fasciae latae muscle immediately distal to the ASIS. A deep proximal extension of the anterior approach endangers the nerve. Injury to the posterior branch can be avoided by a distal incision (small white arrow and dotted line). **Fig. 3-B, right panel** Anterolateral view of a right hip region showing the posterior type of LFCN branching pattern. A strong posterior branch runs laterally over the tensor fasciae latae muscle. Proximal deep dissection to the ASIS should be avoided. **Fig. 3-C, left panel** Schematic drawing of the fan type of LFCN branching pattern. Multiple nerve branches of equal thickness spread over the anterolateral region of the proximal aspect of the thigh, crossing over the tensor fasciae latae muscle and the lateral border of the sartorius. During the anterior approach to the hip joint, injury to some branches of the LFCN cannot be avoided, even with the most lateral and proximally restricted approach (small white arrows). The skin incision (white dotted line) inevitably crosses the nerve branches. **Fig. 3-C, right panel** Anterolateral view of a right hip region showing the fan type of LFCN branching pattern. Multiple nerve branches spread over the anterolateral region of the proximal aspect of the thigh, where the anterior approach to the hip joint is performed. Injury to LFCN branches during the anterior approach to the hip joint cannot be avoided with this branching pattern (in contrast to the other 2 branching patterns).

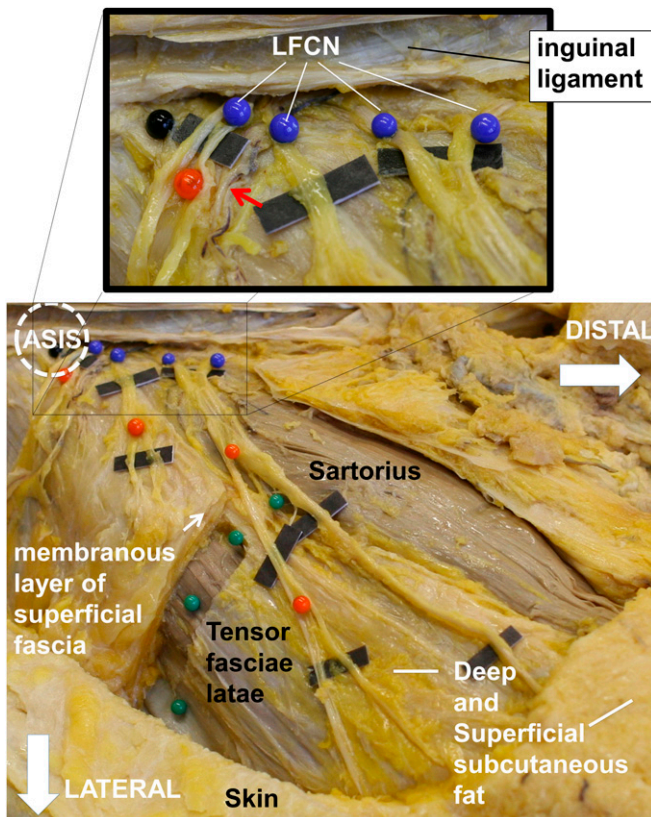


Fig. 5
Anterolateral view of a right hip region showing the fan type of LFCN branching pattern. Black paper was placed beneath the nerve branches for better visualization. The LFCN divided proximal to the inguinal ligament (in the intrapelvic passage). Multiple nerve branches (4 in number, blue dots) pierce the inguinal ligament and spread over the anterolateral region of the proximal aspect of the thigh, crossing over the tensor fasciae latae muscle and the lateral border of the sartorius. Proximal nerve branches course together with fine vessels (red arrow, upper panel). Nerve branches run within a weak fascia (membranous layer) that divides the subcutaneous fat tissue into a superficial and a deep fat layer. The orange dots mark the point where LFCN branches cross either the lateral border of the sartorius or the anterior border of the tensor fasciae latae. The green dots indicate (from medial to lateral) the lateral border of the sartorius, the anterior border, and the middle and the posterior border of the tensor fasciae latae.

permanent, or result in dysesthesia or meralgia paresthetica. The reported rate of injury of the LFCN with the anterior approach varies considerably, from 0.1% to 81%^{15-17,37,38}. This variation may be explained by different interpretations or lack of recognition of LFCN injury, or the diversity of skin incisions chosen for the anterior approach^{2,16,33,34,38}. While some authors observed that most symptoms of LFCN paresthesia resolved after 6 to 24 months¹², others reported only a small number of patients with complete resolution¹³.

The present study showed that 2 parameters influence the potential risk of LFCN injury: the individual distribution pattern of the LFCN in the proximal aspect of the thigh, and the technique and skin incision used for the anterior approach.

With a sartorius type of LFCN pattern (found in 36% of the hemipelves that we studied), the injury to the nerve can be avoided by a more lateral incision away from the lateral border of the sartorius muscle (Fig. 3-A). In these particular cases, as reported by Judet and Judet³⁵, the anterior superficial aponeurosis of the tensor fasciae latae protects the dominant anterior branch of the LFCN (Fig. 4). Therefore, damage to the LFCN can be easily avoided.

With a posterior type of LFCN pattern (found in 32% of the hemipelves that we studied), even a more lateral incision would not prevent damage to the posterior branch in its proximal aspect (Fig. 3-B). Care should be taken when the approach requires greater access proximal to the ASIS. Most importantly, in this area, the skin incision should be restricted to the superficial level of the two-layered subcutaneous soft tissue, as the posterior branch of the LFCN runs regularly within a membranous sheet of the subcutaneous tissue (Figs. 2, 3-C, and 5). The posterior branch can be protected by blunt dissection and proximal mobilization together with its accompanying vessels. With a deep proximal extension of the anterior approach, including removal of the tensor fasciae latae from the anterolateral aspect of the iliac crest^{34,35}, the posterior branch cannot be preserved from damage, resulting in sensory dysfunction in the lateral thigh or trochanteric region³⁷.

With a fan type of nerve pattern (found in 32% of the specimens that we studied), injury to some branches of the LFCN cannot be avoided, even with the most lateral and proximally restricted approach (Fig. 3-C).

On the basis of our findings, with carefully placed incisions, careful dissection, and confining the anterior approach to the hip to the area inferior and lateral to the ASIS, the injury rate to branches of the LFCN should not exceed one-third of all cases. Additionally, if a proximal extension of the anterior approach to the hip joint is necessary, as with pediatric orthopaedic surgery for developmental hip dysplasia⁷ or in revision arthroplasty^{4,39}, additional damage to the posterior branch of the LFCN must be expected. Under these circumstances, and in cases of a well-expressed posterior branch (posterior-type, 32% of the specimens studied), dysesthesia in the lateral thigh and gluteal region is inevitable.

Ropars et al.³¹ dissected the LFCN bilaterally in 17 human cadavers and recorded the branching pattern of the nerve. On the basis of their measurements, using the anterior margin of the tensor fasciae latae and the ASIS as landmarks, they defined 3 zones of differing risk for the anterior branch, the posterior branch, and both branches of the LFCN. The nerve was found to be potentially at risk between 27 and 92 mm distal to the ASIS where it crossed the anterior border of the tensor fasciae latae muscle. Consistent with the present study, they also recommended to position the skin incision as lateral and distal as possible.

However, a predetermined skin incision more lateral and distal may be undesirable, as it does not correspond to the internervous plane of the anterior approach to the hip joint and, therefore, prevents good visualization and access to the operative area. In contrast to previous investigations, the present study provides information about the course of the LFCN within the layers of subcutaneous fat. The superficial and deep subcutaneous

fat layers are divided by a discrete membranous layer (Figs. 3-C and 5). At the site where the anterior approach is performed, the LFCN consistently ran within this membranous layer deep in the subcutaneous fat (Fig. 2). Proximal branches were generally accompanied by fine vessels (Fig. 5). This information is also of interest when neurolysis of the LFCN⁴⁰ or an ultrasound-guided LFCN block⁴¹ has to be performed. Therefore, a skin incision at the ASIS is not problematic per se, as long as the incision remains in the superficial subcutaneous fat layer. Nerve branches of the LFCN, which are not always visible at first glance during surgery, can be gently shifted by blunt dissection proximally and medially together with the membranous layer and the deep subcutaneous fat. Rigorous use of retractors into the subcutaneous soft tissue should be avoided. Membranous layers have been described in other areas of the human body. In the lower anterior abdominal wall and the peritoneum, it has been named Scarpa fascia or Colles fascia, respectively^{30,42,43}. Markman and Barton studied the anatomy of the subcutaneous fat tissue in the trunk and extremities and confirmed the presence of a membranous layer in the thigh⁴⁴. Others noted that the anatomy of the membranous layer varied with sex, adiposity, and body region⁴⁵ and that it was thicker in the lower compared with the upper extremity and on the posterior compared with the anterior aspect of the body⁴⁶.

Many anatomical studies have described the LFCN anatomy and its variations in relation to the ASIS, the approach for iliac crest bone harvesting, or the surgical management of meralgia paresthetica^{19,26,40}. In the present study, most LFCN branches entered the thigh above (27%) or medial to (62%) the ASIS. In 11% of the specimens, nerve branches were found crossing the iliac crest lateral to the ASIS (Fig. 1). These results are consistent with previous observations, wherein a lateral course of the LFCN was found in 4% to 19% of cases^{19,20,25,47,48}. In particular, a lateral course of an LFCN branch must be considered in cases when a proximal extension of the anterior approach to the hip joint is needed.

In the present study, the LFCN divided superior to the inguinal ligament in 50% of the cases, which is a far greater percentage than described by others (28% to 38%)^{23,31}. This might be because, in contrast to the methods of previous investigations, the present dissections began proximal to the inguinal ligament in the intrapelvic space. From there, the LFCN branches were traced distally. This method may decrease the risk of missing the identification of nerve branches. In 50% of the dissected limbs, 2 to 4 nerve branches could be found. Three, 4, and even 5 LFCN

branches have been observed in other studies^{23,24}. Variations have been described, where the LFCN is replaced by the femoral branches of the genitofemoral nerve or anterior branches of the femoral nerve⁴⁹. No such finding was observed in the present study.

The results of this study suggest that, in approximately one-third of patients in whom an anterior approach to the hip joint is used, certain injury to the LFCN cannot be avoided (see fan-type, Fig. 3-C). Patients undergoing this approach should therefore be informed of the risk. The following intraoperative modifications may minimize LFCN injury during the anterior approach to the hip joint. The skin incision should be as lateral as possible over the anterolateral aspect of the tensor fasciae latae muscle. A strict subfascial dissection (beneath the superficial aponeurosis of the tensor fasciae latae) and above the tensor fasciae latae muscle fibers will protect the anterior branches of the LFCN but not the posterior branches of the LFCN. The posterior branch of the LFCN is most vulnerable in the proximal aspect of the anterior approach. Therefore, a proximal extension of the skin incision should be limited to the superficial subcutaneous fat layer and not enter the membranous layer. If surgery necessitates a deep proximal extension, damage to the posterior branch is most likely, as is damage to the entire LFCN if the nerve courses laterally in relation to the ASIS. ■

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